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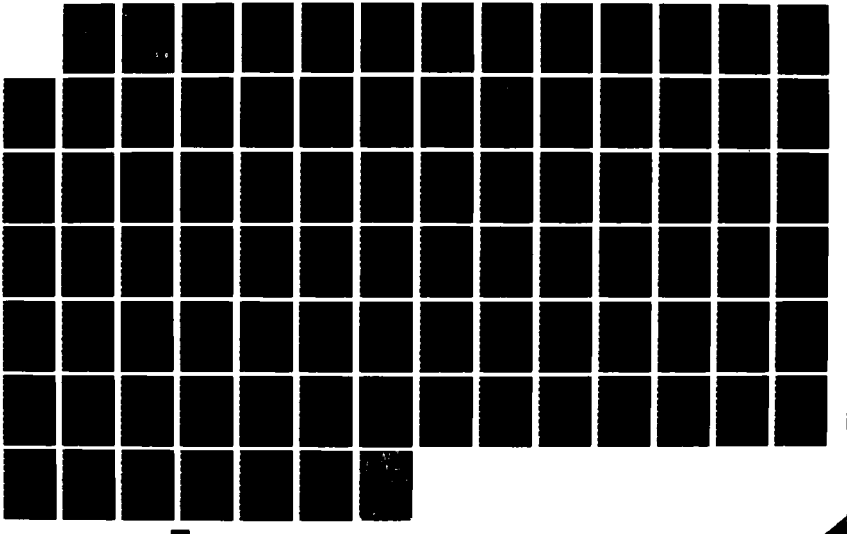

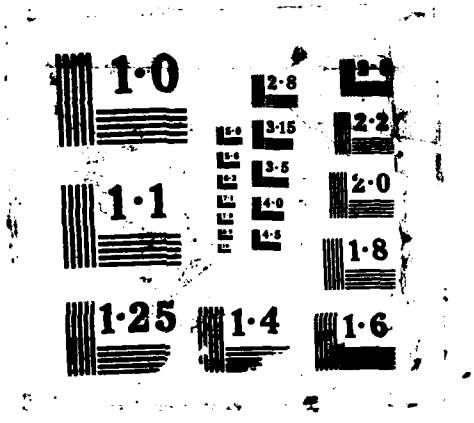
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by

Mary Katherine Higgins, Major, USAF
Master of Science in Operations Research, Massachusetts Institute of Technology, 1987

ABSTRACT

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The calculations suggest substantial divergence of risk across groups of airlines with the U.S. domestic trunk lines and large international flag carriers significantly outperforming the small international airlines and "children" of U. S. airline deregulation. At the same time, the general trend has been toward major reductions over time in air travel risk.

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KEY SOURCES

1. Barnett, Arnold; Abraham, Michael; Schimmel, Victor; "Airline Safety: Some Empirical Findings," Management Science 25 (November 1979): 1045-1056.

2. Air Carrier Traffic Statistics, published monthly by U.S. Civil Aeronautics Board, various editions 1977-1986.

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AIRLINE SAFETY: A COMPARATIVE ANALYSIS

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B.A., Saint Xavier College
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AIRLINE SAFETY: A COMPARATIVE ANALYSIS

by

Mary Katherine Higgins

Submitted to the Department of Electrical Engineering and Computer Science
on January 22, 1987 in partial fulfillment of the
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ABSTRACT

In this study of airline safety, we will focus on fatal accidents, considering the records of U.S. domestic airlines and international air carriers over the past ten years. We estimate a passenger's probability of being killed on a given flight using data from each of 157 airlines (35 U. S. domestics and 122 internationals).

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CHAPTER 1
INTRODUCTION

Although airline travel has become essentially routine, concern over airline safety seems to have increased in recent years. The increased concern is hardly surprising in light of the intensive media coverage of any airline accident, complete with photographs and interviews. The media has also kept us aware of alleged drug abuse by air traffic controllers and even airline pilots. In addition, we are reminded of the slow recovery of the air traffic control system since the 1981 strike with the attendant safety problems. We have also heard from the opponents of the Airline Deregulation Act of 1978 who insist that the act has had a negative impact on U.S. domestic airline safety. All of these, though, have been overshadowed by the terrorist threat with 20 hijackings and 14 other cases of sabotage aboard commercial airliners around the world in 1985 alone [14].

These concerns have generated more than just rhetoric. In terms of the impact of airline deregulation, Congress has required that the Department of Transportation submit "an annual report on the extent to which implementation of the Act has affected the level of air safety in the preceding calendar year..." [9]. The American public has responded to the terrorist threat by cutting back on its air travel from the U.S. to Europe, with the Travel Industry Association of America reporting a ten percent decrease in such travel from June 1985 to June 1986 [14]. The airlines themselves had changed their plans for the summer of 1986 with Trans World Airlines reducing service to the

Mediterranean area and Eastern Airlines postponing planned service to Madrid, Spain [14].

The purpose of this analysis is to determine if there is justification for the recent concern over airline safety, and if there is cause, whether any particular airline or airlines seem to be significantly less safe than the others. To do this, I will examine safety levels in the international air carriers and the U.S. domestic airlines from an historical perspective by comparing their past safety performance with that of recent years. I will then take a detailed look at their recent safety performance in comparison to other airlines working a similar route structure.

I will begin my analysis by outlining the sort of work that has been done in the field of airline safety analysis, noting that there are surprisingly few airline-by-airline comparisons. In Chapter Three I will describe the methodology I used to conduct this study. I feel compelled to devote some space to the methods of raw data collection, as this was, perhaps, the most time-consuming part of the entire process. In the remainder of the chapter I will explain the measures of safety used, and the methods employed in comparing individual airline's safety records. Finally, in Chapter Four I will summarize my results and draw (and not draw) some conclusions in Chapter Five.

CHAPTER 2
LITERATURE SEARCH

There is a considerable body of work in the analysis of levels of airline safety. The initial work in this area was stimulated by the need to convince the public of the safety of a new and very different mode of transportation. Through the years, the motivation has changed into an effort to respond to the flood of information from the media about airline accidents, terrorism, maintenance procedures, and the entire air travel environment.

In my literature search, I have found four studies which represent a reasonable survey of the types of analyses conducted to date. They are the U.S. Department of Transportation's annual study mandated by Congress [9], a comparison of national airline records by J. M. Ramsden [6,7], an analysis of commuter airline safety by Clinton V. Oster, Jr. and C. Kurt Zorn [5], and finally, an analysis of international and U.S. domestic airline safety by Arnold Barnett, Michael Abraham, and Victor Schimmel. I will discuss the four airline safety studies in terms of the measures of safety used, the units of analysis (airline, nation, or groups of airlines), and briefly, the results of the particular analysis.

2.1 U.S. Department of Transportation (DOT) Study

In their annual post-deregulation analysis, the Department of Transportation (DOT) examines all facets of commercial aviation in the U.S.

I shall focus on their study of air carrier safety as published in their report on activities in calendar year 1984 [9].

2.1.1 DOT's Measures of Safety

There are basically three measures of safety used by the DOT: accident rate per 100,000 hours flown, accident rate per million miles flown, and accident rate per 100,000 departures. Within each of these three categories is a total accident rate and a fatal accident rate. Before I look at the three safety measures in more detail, I will discuss the problems inherent in determining a total accident rate.

A total accident rate is difficult to determine because of the procedures for reporting accidents. Perhaps because of an airline's understandable sensitivity to public knowledge of its accidents, one has little assurance that each airline reports every accident or incident [7]. One can be reasonably certain though, that fatal accidents are accurately reported. Therefore, a measure based on fatal accidents would seem to be the most accurate, available means for comparing safety levels.

A fatal accident rate per 100,000 hours flown or per million miles flown, while taking care of the above problem, has other limitations. A measure based on fatal accidents per hour or mile flown ignores the fact that an airline which flies more frequent, shorter flight segments than other airlines would be exposed to more takeoffs and landing than the others. Since, by far, the most accidents occur during takeoff and landing (over 70% if one considers only the

fatal accidents of the 11-year period studied in this thesis), this measure would unduly penalize the airline flying frequent short segments.[1]

The third and final measure is also not without limitations. A fatal accident rate per 100,000 departures, while not unduly penalizing the short-haul carrier, does not differentiate between an accident in which only one passenger dies and an accident in which all on board perish.

2.1.2 DOT's Units of Analysis

Previously the DOT grouped airlines by route authority such as "trunk", "regional", "local", and so on. Beginning with the January 1986 report, the airlines are broken into three groups, certificated air carriers, commuter airlines and air taxi operators. There is no breakdown by individual airline [9].

2.1.3 Results of the DOT Study

Because its interest was in determining the effect of deregulation on airline safety, the DOT compared the record of a particular segment of commercial aviation to its own record in previous years, starting with 1978. The DOT's analysis of 1984 air carrier activity indicated a decline in total accident and fatal accident rates in 1984 as compared to previous years. The DOT also commented that the 1984 annual record was the best since enactment of the

[1] In the study performed by Barnett, Abraham and Schimmel [1], the independence of flight risk and flight length was established by performing an hypothesis test on the differences in the distribution of flight segment lengths in the U.S. and the distribution of flight segment lengths of U.S. airliners involved in fatal crashes over a 20 year period (1957-1976).

Airline Deregulation Act [9].

2.2 Ramsden's Studies

J.M. Ramsden of Flight International has published several analyses, comparing national airline's safety records. In his two most recent studies (January 1979 and 1985), he uses two measures of safety which involve passenger risk [6,7].

2.2.1 Ramsden's Measures of Safety

According to Ramsden, the most important measure of safety is the number of fatal accidents per million flights. The other measures are the number of fatalities per million flights, and two measures based on capacity tonne-kilometer (CTK). CTK is intended to account for the total air transport production of each country and is the total passenger capacity and cargo tonnage offered [6,7]. Because my interest is in passenger risk, I shall discuss only the first two measures in detail.

The first thing that one notices is that the four measures used involve only fatal accidents. There are two reasons cited for narrowing the field of study to fatal accidents. One is the fact that there are differences among nations in the very definition of accident. The other reason is that nations rarely publish lists of airline accidents [7]. And, as I mentioned earlier, it is reasonable to assume that the fatal accidents are accurately reported in most countries. The one major exception to this premise is the sketchy reporting from the Soviet Union with respect to its airline, Aeroflot [7].

The first (and in Ramsden's opinion, most important) measure, the number of fatal accidents per million flights, treats as equivalent any accident involving fatalities, whether a few or many. This measure, with the number of flights equal to the number of departures, is the same as the one used in the DOT study and has the same limitations.

The second measure, the number of fatalities per million flights is also deficient in that it doesn't account for aircraft size. In using this measure to compare airlines flying the same number of flights, one would consider an airline which experiences a single crash of a DC-10 with no survivors as safe as an airline which experienced four unsurvivable DC-9 crashes.

2.2.2 Ramsden's Units of Analysis

In order to compare national airline safety records, Ramsden combined the fatality and activity records for all airlines in each particular country. He included scheduled, nonscheduled, passenger and cargo flights flown by airlines of 18 nations in his 1979 and 1985 studies, and comments on the airlines of seven additional nations in the 1985 study [6,7].

2.2.3 Results of Ramsden's Analysis

In the 1979 study which covered 1973-1978, Ramsden computed the average performance of the ten safest countries with respect to each of the four measures. The following is an alphabetical list of the countries he found to be above average in the primary measure of fatal accidents per million flights: Australia, Belgium, West Germany, Italy, Japan , Scandinavia, United Kingdom, and United States. The above average performers with respect to all four

measures were, alphabetically, Australia, West Germany, Japan, Scandinavia, United Kingdom and United States [6].

In his 1985 study which covered 1973-1984, Ramsden ranked the nations based on the primary measure. His results are shown in Table 2.1 [7].

Ranking	Nation	Ranking	Nation
1	Australia	10	Netherlands
2	Scandinavia	11	Canada
3	Japan	12	Argentina
4	United States	13	Venezuela
5	France	14	Brazil
5	United Kingdom	15	India
5	West Germany	16	Egypt
8	Italy	17	Turkey
9	Belgium	18	Colombia

Table 2.1 Ramsden's Ranking of National Airline Safety Records from 1973-1984 According to Fatal Accidents per Million Flights

He then used what he called "statistical license" and added the rankings from each of the four measures considered separately to produce a final ranking shown in Table 2.2 [7].

Ramsden noted that overall, the number of fatal crashes per million flights has decreased from a typical figure of 67 per million[1] 50 years ago, to 2.5 in

[1] This figure was for Imperial Airlines (UK) which Ramsden says was by no means the world's worst [7].

Ranking	Nation	Ranking	Nation
1	Australia	10	Italy
2	France	11	Argentina
2	Japan	12	Netherlands
4	Scandinavia	13	Brazil
5	West Germany	14	Venezuela
6	United States	15	India
7	United Kingdom	16	Egypt
8	Belgium	17	Turkey
8	Canada	17	Colombia

Table 2.2 Ramsden's Ranking of National Airline Safety Records from 1973-1984 Based on Combined Rankings of the Four Safety Measures

1963-1972, and to 1.9 in 1973-1984. He also applauds the following countries for their performance over 30 years of Flight International's safety audits: Australia, France, West Germany, Japan, Scandinavia, United Kingdom, and the United States (alphabetical order) [7].

2.3 Oster and Zorn's Study

In 1984, Clinton V. Oster, Jr., and C. Kurt Zorn conducted an analysis of airline safety among commuter airlines in the United States. In their study covering the years 1970 to 1980, they examined commuter safety in terms of three different measures.

2.3.1 Oster and Zorn's Measures of Safety

Oster and Zorn first used the measure of passenger fatalities per 100 million passenger miles, acknowledging its shortcomings which I described in

subsection 2.1.1. The second measure they examined was that of passenger fatalities per 100,000 aircraft departures. They pointed out its deficiency in its failure to account for the different sizes of aircraft [5].

Because of the limitations of the first two measures, Oster and Zorn's measure of choice was passenger fatalities per one million passenger enplanements. As an example of what an enplanement can involve, consider a passenger who boards an aircraft in Albany, New York bound for Buffalo. If the aircraft makes intermediate stops in Syracuse and Rochester, the passenger is counted as one enplanement even though he or she has experienced three flight segments with their associated takeoffs and landings. Oster and Zorn observed that this measure could slightly overstate the risk for nonstop flights while slightly understating risk for multistop flights [5].

2.3.2 Oster and Zorn's Units of Analysis

Because they were investigating reports that the commuter airlines were 10 to 30 times less safe than the certificated jet carriers, Oster and Zorn confined their study to those airlines [5].

2.3.3 Oster and Zorn's Results

When they used passenger fatalities per 100 million passenger miles, Oster and Zorn found that from 1977-80, the commuters were indeed 10 to 30 times less safe than the certificated jet carriers. However, when they relied on the measure of passenger fatalities per 100,000 aircraft departures, Oster and Zorn found that the commuters had a lower accident rate than the larger carriers in

three of the six years studied (1975-80). They also found that the commuters had an average fatality rate of 1.1 while the certificated jet rate was 3.4 [5].

In using their measure of choice (passenger fatalities per one million enplanements), Oster and Zorn found that in the period 1970-80, the commuters were, on the average, three times less safe than the certificated jet carriers. Using this last measure, they also examined intraindustry safety. They divided the commuter airlines into two groups: the top 20 (in terms of passenger enplanements) and the others. The top 20 were over five times safer than the others and nearly as safe as the certificated jet carriers [5].

2.4 The Barnett, Abraham and Schimmel (BAS) Study

In 1979, Arnold Barnett, Michael Abraham, and Victor Schimmel published their study of airline safety reviewing accident records of U.S. domestic and major international airlines.

2.4.1 Measures of Safety in the BAS Study

To measure flight activity, Barnett Abraham and Schimmel (hereinafter BAS) used the number of flights, but rather than using the number of fatalities or fatal accidents, they compute what they call a cumulative fatality quotient (CFQ). The CFQ is found by summing over all flights of interest the fraction of passengers who did not survive each. They then divide this CFQ (a measure of an airline's total accident level) by the number of flights performed to produce an average fatality quotient (AFQ). This overall safety measure (the AFQ) can be interpreted as the probability of dying in an accident were a passenger to have picked a flight and seat at random from the period in question [1].

2.4.2 Units of Analysis in the BAS Study

The BAS study compares the fatal accident records of 18 U.S. domestic airlines from 1957-76, and 40 international airlines from 1960-75.

2.4.3 Results of BAS Study

In comparing the U.S. domestic airlines to each other, BAS found that there was no evidence to support the belief that any particular airline was any more or less safe than the others, because any perceived differences in their safety records could be explained by chance alone [1].

When they compared the international flag carriers to each other, BAS found that, unlike the U.S. domestics, there were statistically significant differences in the safety records of some of the carriers. They found it useful to divide the 40 international airlines by size, designating an airline as large if it averaged over 20,000 flights per year over the period studied, and small otherwise. BAS found that they had sufficient evidence to consider these airlines equally safe within their respective groups[1].

In general, BAS found an over 50% improvement in the fatality rates of airlines in all segments from the early 1960s to the mid 1970s. They also concluded that, as a group, the U.S. domestics were safer by a factor of four than the large international airlines studied and safer than the small international carriers by a factor of 16 [1].

Because the BAS study provides the most reasonable overall measure of safety (AFQ), I will follow the same general methodology for the analysis which follows.

CHAPTER 3
METHODOLOGY

The intent of this analysis is to measure airline safety in terms of passenger risk for scheduled flights on international as well as U.S. domestic airlines. Although the primary emphasis will be on U.S. domestic airlines, I shall examine the international airlines' records to see if the U.S. domestics have maintained their pre-deregulation superiority in terms of safety. I shall also study the international airlines for the sake of completeness, to continue the BAS study.

To accomplish this, I had to first choose which airlines to include, collect accident and traffic data for each, and then apply a measure of safety. I will *begin with my criteria for* including airlines in this study.

3.1 Airline Choice

I will break out my airline choices for international and U.S. domestic carriers below.

3.1.1 International Airlines

To begin with, I will examine data for 39 of the 40 international airlines which were included in the BAS study. The original group of 40 had been chosen because they generated, by far, the majority of international traffic. I am only studying 39 because the data for the East African airline were unavailable. The airlines from the BAS study are listed in Table 3.1. They are

International	Airlines
Aer Lingus	Lan Chile
Aeromexico	Loftleider (now Icelandair)
Air Canada	LOT (Poland)
Air France	Lufthansa
Air India	Malev (Hungary)
Alitalia	Nigeria
Argentinas	Olympic
AUA (Austria)	PIA (Pakistan)
Avianca (Colombia)	Pan American
British Airways	PAL (Philippines)
East African	Qantas
Egyptair	Sabena
El Al	SAS
Ethiopian	SAA (South Africa)
Finnair	Swissair
Iberia (Spain)	TAP Air Portugal
Iran Air	THY (Turkey)
JAL (Japan)	TWA
JAT (Yugoslavia)	Varig (Brazil)
KLM	Viasa (Venezuela)

Table 3.1 International Airlines from BAS Study

also shown grouped by traffic volume as they were in the BAS study in Table 3.2.

Large	Airlines	Small	Airlines	
Aer Lingus	Lufthansa	Aeromexico	Finnair	Olympic
Air Canada	Pan Am	Air India	Iran Air	PIA
Air France	Sabena	Argentinas	JAL	PAL
Alitalia	SAS	AUA	JAT	Qantas
British	Swissair	Avianca	Lan Chile	SAA
Iberia	TWA	East African	Loftleidir	TAP
KLM		Egyptair	LOT	THY
		El Al	Malev	Varig
		Ethiopian	Nigerian	Viasa

Table 3.2 International Airlines from BAS Study, Grouped by Traffic Volume

I will then study the records of the 83 additional airlines which reported international traffic data to the International Civil Aviation Organization

(ICAO) during essentially the entire period from 1976 to 1985. Aeroflot is not included because its first traffic data report was in 1982.

3.1.2 U.S. Domestic Airlines

As with the international airlines, I will begin with the airlines from the original BAS study. The 18 airlines listed in Table 3.3 had been chosen because they were the principal U.S. domestic trunk carriers during the time period studied by BAS (1957-76).

Airline
American
Braniff
Continental
Delta
Eastern
Frontier
Hughes Airwest
National
North Central
Northwest
Ozark
Piedmont
Southern
Texas International
TWA
United
U.S. Air (Allegheny)
Western

Table 3.3 U.S. Domestic Trunk Carriers--BAS Study

The same airlines operated during the period of this study (1977-1986), but some have been combined because of mergers. Therefore, I will consider Hughes Airwest, North Central, and Southern together as Republic since it was formed in 1979, near the beginning of the period considered (1977-1986). Another 1979 change was Pan American's merger with National, so their

combined data will be associated with Pan Am's domestic data. Finally, Texas International merged with Continental in 1982. It will be considered separately for the first half of the ten year period, and its 1982 data will be combined with Continental's for the second half of the period.

Because of the industry-wide interest in the impact of deregulation on safety, I will also consider the records of the new entrant jet carriers, the "children" of deregulation. Candidates for this list had to either be a jet airline with scheduled operations which was formed (or whose scheduled operations began) after October 1978 (corresponding to the enactment of the Airline Deregulation Act), or an existing jet carrier which expanded its operations in the post-deregulation period by at least a factor of five. The following table, Table 3.4, lists the new entrant jet carriers as determined by the above criteria.

Airline
Air Florida
Air One
America West
Arrow Air
Capitol
Florida Express
Jet America
Midway Metrolink
Midwest Express
Muse Air
New York Air
Northeastern International Airways
Pacific East Air
People Express
Sunworld
Transamerica
World

Table 3.4 New Entrant Jet Carriers

All of the carriers in Table 3.4 appeared on the scene for the purpose of conducting scheduled operations after October 1978 with the exception of Air Florida. Of the major pre-deregulation intrastate air carriers (Air Cal, Air Florida, PSA, and Southwest), only Air Florida's traffic increased by more than a factor of five to meet the growth criterion as shown in Table A.1.

3.2 Data Collection

The average fatality quotient (AFQ) is calculated by dividing the cumulative fatality quotient (CFQ) by N, the number of flights flown by an airline or group of airlines of interest. To compute the CFQ, it is necessary to find out the number of passengers killed and the number of passengers on board each aircraft which was involved in a fatal accident during the period in question. Information on the number of flights flown by airlines and passenger data on airliners involved in fatal accidents for the period in question was gathered from many sources.

3.2.1 Traffic Data

The number of flights is represented by the number of departures in the traffic data sources. The primary source was the ICAO Digest of Statistics [15] which provided separate listings for international and domestic activity. Some otherwise unavailable U.S. airline data were extracted from the U.S. Civil Aeronautics Board (CAB) Air Carrier Traffic Statistics [8], and the Official Airline Guide [12].

Because of the irregularity of reports, particularly from some of the smaller international carriers, some estimation procedures were necessary. If partial data were available for a given year, the missing months were assumed to have

the same average traffic count as the reported months. If data were missing for an entire year, the data from the years on either side of the year in question were averaged to produce the estimate for the missing figure. Missing data from the beginning or end of the period were assumed to be approximately equal to the nearest year's data. In the same manner, the traffic for 1986 was estimated to be the same as 1985's, since it will be month before 1986 data will be available.

These estimation rules assume a fairly constant behavior pattern for airline traffic, certainly no more than a gradual increase or decrease in traffic levels. While this is generally the case, those rare cases where a steadiness does not hold true should only affect by a small percentage the magnitude of the total traffic figures. Such "perturbations" should have little effect on aggregate safety statistics.

Tables A.2 - A.6 indicate which data were estimated and how they were estimated.

3.2.2 Accident Data

The main source for fatal accident data on scheduled airlines was the annual safety report published in the January issues of Flight International [11]. 1986 data were obtained from weekly issues of Flight International [11], the United Kingdom's Civil Aviation Authority's World Airline Accident Summary [16], and the New York Times [14].

All accidents on scheduled airlines which involved passenger fatalities were considered. This included fatalities due to hijacking, sabotage, or terrorist

activity. These had been included in the BAS study [1] as well as in Ramsden's safety audits [6,7] because it was felt that an airline should be rewarded for its care and expenditures in establishing stringent security procedures, even to the extent of refusing to fly into a location pending need security improvements.

In determining whether to include terrorist actions while the aircraft is on the ground, I will use the U.S. National Transportation Safety Board's definition of an aircraft accident:

> An "aircraft accident" is defined by the NTSB as "an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until all such persons have disembarked, and in which any person suffers death or serious injury as a result of being in or upon the aircraft..." [9]

After obtaining the above list of accidents, the type of flight segment (international or domestic) that the affected aircraft was on had to be determined. This was important to insure that I was only comparing airlines which operated in similar environments. The flight segment information was often not easily obtainable for non-U.S. carriers and had to be extracted from a variety of sources. These included Flight International [11] articles, the CAA World Airline Accident Summary [16], New York Times [14], Aviation Week and Space Technology [10], the Official Airline Guide [13], World Airline Fleets '85 [2], The Airline Handbook [4], and the Aviation Safety Division of ICAO in Montreal. The determination of international or domestic flight segment is indicated in Table A.7 in the appendix for the fatal accidents on scheduled airlines.

Finally, the number of passenger fatalities and number of passengers on board had to be obtained. For this purpose, I did not penalize an airline for deaths among hijackers or terrorists.

The "distilled" accident list for international flights is in Table 3.5. It includes only those fatal accident which occurred when the flight was on an international segment flown by an airline which reported traffic to ICAO from 1976 to 1985.

The "distilled" accident list for U.S. domestic airlines, shown in Table 3.6, includes only fatal accidents of the include U.S. domestic carriers that occurred on scheduled domestic flight segments.

3.3 Measure of Safety

Before applying the safety measures from the BAS study which I discussed in Chapter Two, I broke the data into two time periods. The international data were split into 1976-80 and 1981-1986, while the domestic data were split into 1977-81 and 1982-86. This is in character with the original BAS study which sought to eliminate bias against the older airlines who did more flying when air travel was less safe [1].

I then found the overall accident level for each air carrier in each period by computing its cumulative fatality quotient (CFQ):

$$CFQ = \sum_{i=1}^{n} x_i$$

where x_i = the fraction of passengers who did not survive a give flight i
(of course, most $x_i = 0$)

N = the total number of flights in the period

I was then able to compute the average fatality quotient (AFQ) to form a measure of the overall safety performance of an airline or group of airlines.

$$AFQ = \frac{CFQ}{N} = \frac{\sum_{i=1}^{N} x_i}{N}$$

To correspond to the physical interpretation of AFQ as risk, I expressed the AFQs in the form 1 in X.

The N an CFQ values for the selected carriers are shown in tables 3.7 through 3.12. They have been used to obtain the results that are summarized in the following chapter.

DATE	AIRLINE	TYPE OF AIRCRAFT	PAX DEAD	PAX ON BOARD	RMKS	PHASE
1 Jan 76	MEA	B720	67	67	T	ER
4 Jul 76	Air France	A300	2	240	T	G
10 Sep 76	British Airways	Trident	54	54		ER
6 Oct 76	Cubana	DC-8	50	50	T	ER
25 Dec 76	Egyptair	B707	43	43		App
22 Sep 77	Malev	Tu-134	21	45		L
28 Sep 77	JAL	DC-8	25	69		App
3 Nov 77	El Al	B747	1	?(300)		ER
1 Jan 78	Air India	B747	190	190		T/O
21 Apr 78	KAL	B707	2	97	H	ER
14 Mar 79	Alia	B727	42	49		L
7 Oct 79	Swissair	DC-8	14	142		L
31 Oct 79	Western	DC-10	63	77		L
26 Nov 79	PIA	B707	145	145		ER
3 Mar 80	LOT	Il-62	77	77		RA
10 May 80	Indian Airlines	B737	2	127*		ER
7 Jul 80	Tarom	Tu-154	1	152		RA

Table 3.5 Accident List--International Airlines, 1976-1986

Remarks: T indicates terrorist activity or hijacking
H indicates hostile action

Phase: AA--Airport Approach
App--Approach
C--Climb
ER--Enroute
G--Ground
L--Landing
RA--Runway Approach
T/O--Takeoff

* indicates where only combined crew + passenger total was known--number of crew was estimated and subtracted to give number indicated.

DATE	AIRLINE	TYPE OF AIRCRAFT	PAX DEAD	PAX ON BOARD	RMKS	PHASE
14 Oct 80	THY	B727	1	100*	T	G
19 Nov 80	KAL	B747	8	198		L
23 Dec 80	Saudia	Tristar	2	288		ER
22 Jun 82	Air India	B707	17	99		L
3 Jun 83	Air Canada	DC-9-32	23	41		ER
31 Aug 83	KAL	B747	246	246	H	ER
23 Sep 83	Gulf Air	B737	105	105	PosT	AA
27 Nov 83	Avianca	B747	161	172		AA
12 Dec 83	Iberia	B727	49	84		T/0
1 Jan 85	Eastern	B727-225	21	21		AA
19 Jan 85	Cubana	Il-18	35	35		T/O
15 Jun 85	TWA	B727	1	153	T	G
23 Jun 85	Air India	B747-237B	307	307	T	ER
23 Nov 85	Egyptair	B737	58	98	T	G
2 Apr 86	TWA	B727	4	121	T	ER
3 May 86	Air Lanka	Tristar	16	101	T	G
31 Aug 86	Aeromexico	DC-9	58	58		AA

Table 3.5 Accident List--International Airlines, 1976-1986

Remarks: T indicates terrorist activity or hijacking
H indicates hostile action

Phase: AA--Airport Approach
App--Approach
C--Climb
ER--Enroute
G--Ground
L--Landing
RA--Runway Approach
T/O -Takeoff

* indicates where only combined crew + passenger total was known--number of crew was estimated and subtracted to give number indicated

DATE	AIRLINE	TYPE OF AIRCRAFT	PAX DEAD	PAX ON BOARD	RMKS	PHASE
5 Sep 86	Pan Am	B747	16	398	T	G
25 Dec 86	Iraqi Airways	B737	59*	91	T	ER

Table 3.5 Accident List--International Airlines, 1976-1986

Remarks: T indicates terrorist activity or hijacking
H indicates hostile action

Phase: AA--Airport Approach
App--Approach
C--Climb
ER--Enroute
G--Ground
L--Landing
RA--Runway Approach
T/O--Takeoff

* indicates where only combined crew + passenger total was known--number of crew was estimated and subtracted to give number indicated.

DATE	AIRLINE	TYPE OF AIRCRAFT	PAX DEAD	PAX ON BOARD	RMKS	PHASE
4 Apr 77	Southern Airways	DC-9	60	81		ER
1 Mar 78	Continental	DC-10	2	184		T/O
8 May 78	National	B727	3	52		App
28 Dec 78	United	DC-8	8	177*		App
12 Feb 79	Allegheny	Mohawk 298	1	22		T/O
25 May 79	American	DC-10	259	259		T/O
19 Jan 82	Air Florida	B737	70	74		T/O
23 Jan 82	World Airways	DC-10	2	196		L
9 Jul 82	Pan Am	B727-100	138	138		T/O
9 Jan 83	Republic	Convair 580	1	30		L
2 Aug 85	Delta	Tristar	128	155		RA
6 Sep 85	Midwest Express	DC-9	31	31		T/O

Table 3.6 Accident List--U.S. Domestic Airlines, 1977-1986

Remarks: T indicates terrorist activity or hijacking
H indicates hostile action

Phase: AA--Airport Approach
App--Approach
C--Climb
ER--Enroute
G-Ground
L--Landing
RA--Runway Approach
T/O--Takeoff

* indicates where only combined crew + passenger total was known--number of crew was estimated and subtracted to give number indicated.

AIRLINE	N: 76-80	CFQ	N: 81-86	CFQ
Aer Lingus	126,938	0	162,286	0
Air Canada	210,497	0	231,414	.5610
Air France	651,436	.0083	693,646	0
Alitalia	329,010	0	319,902	0
British Airways	699,800	1.0000	755,854	0
Iberia	326,609	0	406,839	.5833
KLM	314,079	0	374,603	0
Lufthansa	507,509	0	686,456	0
Pan American	373,757	0	420,002	.0402
Sabena	224,487	0	249,235	0
SAS	474,846	0	578,288	0
Swissair	440,572	.0986	451,321	0
TWA	112,986	0	105,718	.0413
TOTALS	4,792,526	1.1069	5,435,564	1.2258
AFQs	1:4,329,683		1:4,434,299	

Table 3.7 Large International Airlines -- BAS Study

AIRLINE	N: 76-80	CFQ	N: 81-86	CFQ
Aeromexico	54,902	0	82,041	1.0000
Air India	75,462	1.0000	88,135	1.1717
Argentinas (Aerolineas Argentina)	87,178	0	83,380	0
AUA (Austria)	121,829	0	162,922	0
Avianca (Colombia)	42,276	0	52,918	.9360
East African	Not in digest of statistics			
Egyptair	66,669	1.0000	105,097	.6122
El Al	47,853	.0033	59,220	0
Ethiopian	31,174	0	40,059	0
Finnair	112,025	0	145,412	0
Iran Air	49,150	0	23,448	0
JAL (Japan)	165,160	.3623	219,835	0
JAT (Yugoslavia)	106,608	0	101,898	0
Lan Chile	30,506	0	24,695	0
Loftleider (now Icelandair)	24,108	0	27,492	0
LOT (Poland)	81,658	1.0000	66,128	0
Malev (Hungary)	58,011	.4667	99,826	0
Nigeria Airways	25,973	0	38,734	0
Olympic	80,364	0	105,389	0
PIA (Pakistan)	74,329	1.0000	91,468	0
PAL (Philippines)	31,993	0	58,414	0
Qantas	83,511	0	103,318	0
SAA (South Africa)	57,226	0	61,618	0

Table 3.8 Small International Airlines--BAS Study

AIRLINE	N: 76-80	CFQ	N: 81-86	CFQ
TAP Air Portugal	58,788	0	75,957	0
THY (Turkey)	35,892	.0100	47,449	0
Varig (Brazil)	62,428	0	69,070	0
Viasa (Venezuela)	50,842	0	60,671	0
TOTALS	1,715,915	4.8423	2,094,594	3.7199
AFQs	1:354,359		1:563,078	

Table 3.8 Small International Airlines--BAS Study

AIRLINES	N: 76-80	CFQ	N: 81-86	CFQ
Aer Lingus	126,938	0	162,286	0
Air Canada	210,497	0	231,414	.5610
Air France	651,436	.0083	693,646	0
Air UK	118,195	0	122,439	0
Alitalia	329,010	0	319,902	0
American	139,019	0	180,682	0
AUA (Austria)	121,829	0	162,922	0
British Airways	669,800	1.0000	755,854	0
British Caledonian	102,800	0	134,464	0
Eastern	183,083	0	255,399	1.0000
Finnair	112,025	0	145,412	0
Gulf Air	145,102	0	218,578	1.0000
Iberia (Spain)	326,609	0	406,839	.5833
JAL (Japan)	165,160	.3623	219,835	0
KLM	314,079	0	374,603	0
Lufthansa	507,509	0	686,456	0
Pan Am	373,757	0	420,002	.0402
Sabena	224,487	0	249,235	0
SAS	474,846	0	578,288	0
Saudia	86,315	.0069	136,394	0
SIA (Singapore)	148,763	0	186,541	0
Swissair	440,572	.0986	451,321	0
TOTALS	6,001,831	1.4761	7,092,512	3.1845
AFQs	1:4,066,006		1:2,227,198	

Table 3.9 Large International Airlines -- Entire Group

AIRLINE	N: 76-80	CFQ	N: 81-86	CFQ
Aerolin Dominicanas (Dominican Republic)	3,200	0	2,889	0
Aerolineas Argentina	87,178	0	83,380	0
Aeromexico	54,902	0	82,041	1.0000
Aeroperu	17,407	0	19,850	0
Air Afrique (Yaounde Treaty States)	58,312	0	65,888	0
Air India	75,462	1.0000	88,135	1.1717
Air Jamaica	39,712	0	36,245	0
Air Lanka	13,628	0	32,354	.1584
Air Madagascar	7,882	0	5,833	0
Air Malawi	8,312	0	13,017	0
Air Malta	16,285	0	25,888	0
Air Mauritius	12,187	0	31,499	0
Air New Zealand	38,148	0	40,865	0
Air Niugini (Papua New Guinea)	8,320	0	10,308	0
Air Panama	15,852	0	16,770	0
Air Zaire	11,909	0	10,021	0
Alia (Jordan)	51,762	.8571	88,926	0
Alisarda (Italy)	1,429	0	2,098	0
ALM (Netherlands Antilles)	21,516	0	28,999	0
ARCO (Uruguay)	8,829	0	10,464	0
Ariana (Afghanistan)	10,922	0	8,023	0
Avianca (Colombia)	42,276	0	52,918	.9360
Aviateca (Guatemala)	21,331	0	13,069	0

Table 3.10 Small International Airlines--Entire Group

AIRLINE	N: 76-80	CFQ	N: 81-86	CFQ
Bangladesh-Biman	14,732	0	23,193	0
British Midland	19,006	0	19,372	0
BWIA (Trinidad Tobago)	47,335	0	64,141	0
Cameroon	9,060	0	9,233	0
Caribbean (Barbados)	2,579	0	2,436	0
Cathay Pacific (Hong Kong)	94,357	0	124,140	0
CDA (Dominicana-Dominican Republic)	19,982	0	34,127	0
COPA (Panama)	18,725	0	23,170	0
CP Air (Canada)	45,218	0	53,685	0
Cruzeiro (Brazil)	22,658	0	21,816	0
CSA (Czechoslovakia)	62,883	0	77,336	0
Cubana	7,322	1.0000	10,068	1.0000
Cyprus	26,828	0	35,664	0
Dan-Air (UK)	32,328	0	59,567	0
Delta	44,508	0	55,402	0
Ecuatoriana (Ecuador)	22,781	0	28,335	0
Egyptair	66,669	1.0000	105,097	.6122
Ethiopian	31,174	0	40,059	0
El Al	47,853	.0033	59,220	0
Faucett (Peru)	2,386	0	4,034	0
Frontier	13,704	0	32,707	0
Garuda (Indonesia)	59,426	0	78,690	0
Ghanair	15,501	0	13,154	0

Table 3.10 Small International Airlines--Entire Group

AIRLINE	N: 76-80	CFQ	N: 81-86	CFQ
Icelandair	24,108	0	27,492	0
Indian Airlines	25,926	.0157	35,436	0
Iran Air	49,150	0	23,448	0
Iraqi Airways	37,338	0	38,823	.6483
JAT (Yugoslavia)	106,608	0	101,898	0
KAL (Rep. of Korea)	78,283	.0610	112,385	1.0000
Kuwait Airways	59,250	0	84,299	0
LAB (Bolivia)	15,760	0	20,926	0
LACSA (Costa Rica)	35,267	0	36,233	0
LADECO (Chile)	2,160	0	9,724	0
Lan Chile	30,506	0	24,695	0
LAV (Venezuela)	12,118	0	16,734	0
Libyan Arab	22,730	0	39,075	0
LOT (Poland)	81,658	1.0000	66,128	0
Malev (Hungary)	58,011	.4667	99,826	0
MAS (Malaysia)	78,815	0	136,488	0
MEA (Lebanon)	65,038	1.0000	76,689	0
Merpati Nusantara (Indonesia)	2,551	0	636	0
Mexicana	73,101	0	92,727	0
NLM (Netherlands)	47,231	0	76,181	0
Nigeria Airways	25,973	0	38,734	0
Nordair (Canada)	6,507	0	14,658	0
Northwest	59,338	0	103,707	0
Olympic	80,364	0	105,389	0
Pacific Western (Canada)	16,248	0	10,707	0
PAL (Philippines)	31,993	0	58,414	0

Table 3.10 Small International Airlines--Entire Group

AIRLINE	N: 76-80	CFQ	N: 81-86	CFQ
PIA (Pakistan)	74,329	1.0000	91,468	0
Pluna (Uruguay)	30,941	0	25,889	0
Qantas	83,511	0	103,318	0
Republic	71,939	0	62,169	0
Royal Air Maroc (Morocco)	81,451	0	80,861	0
Royal Nepal	11,885	0	19,785	0
SAA (South Africa)	57,226	0	61,618	0
SAHSA (Honduras)	32,658	0	34,894	0
SAM (Colombia)	5,019	0	5,544	0
Syrian Arab	35,455	0	38,995	0
TAAG-Angola	4,020	0	11,117	0
TAC (Thailand)	5,698	0	11,847	0
TACA (El Salvador)	52,575	0	53,841	0
TAN (Honduras)	15,352	0	18,605	0
TAP Air Portugal	58,788	0	75,957	0
Tarom (Romania)	43,946	.0066	30,172	0
Thai Internartional	70,026	0	116,934	0
THY (Turkey)	35,892	.01	47,449	0
Tunis Air	52,036	0	73,113	0
TWA	112,986	0	105,718	.0413
United	23,654	0	52,000	0
US Air	57,617	0	76,595	0
UTA (France)	77,010	0	63,228	0
Varig (Brazil)	62,428	0	69,070	0
Viasa (Venezuela)	50,842	0	60,671	0
Western	71,589	.8182	86,877	0
Zambia Airways	12,073	0	11,746	0

Table 3.10 Small International Airlines--Entire Group

AIRLINE	N: 76-80	CFQ	N: 81-86	CFQ
TOTALS	3,789,158	8.2386	4,713,491	6.5679
AFQs	1:459,927		1:717,656	

Table 3.10 Small International Airlines--Entire Group

AIRLINE	N: 77-81	CFQ	N: 82-86	CFQ
American	1,653,904	1.0000	1,835,573	0
Braniff	945,999	0	120,231	0
Continental	699,667	.0109	800,845	0
Delta	2,614,593	0	2,549,287	.8258
Eastern	2,586,363	0	2,448,540	0
Frontier	947,659	0	609,264	0
Republic (from Hughes, North Central and Southern)	2,507,926	.7407	2,001,056	.0333
Pan Am (including National)	552,508	.0577	314,304	1.0000
Northwest	716,747	0	762,078	0
Ozark	665,468	0	552,355	0
Piedmont	861,221	0	1,330,015	0
Texas International	436,746	0	merged with Continental Oct 82	
TWA	1,257,390	0	953,697	0
United	2,396,797	.0452	2,308,000	0
US Air (Allegheny)	1,399,814	.0454	1,575,562	0
Western	689,832	0	723,300	0
TOTALS	20,932,625	1.8999	18,882,107	1.8591
AFQs	1:11,017,750		1:10,156,585	

Table 3.11 U.S. Domestic Airlines--BAS Study

AIRLINE	N: 79-86	N includes estimate for 1986?	CFQ
Air Florida	180,286	no	.9459
Air One	6,005	no	0
America West	142,998	yes	0
Arrow Air	9,176	no	0
Capitol	20,225	no	0
Florida Express	45,776	yes	0
Jet America	20,581	no	0
Midway Metrolink	189,936	yes	0
Midwest Express	11,435	yes	1.0000
Muse Air	151,804	yes	0
New York Air	232,357	yes	0
Northeastern International Airways	60,077	no	0
Pacific East Air	1,751	no	0
People Express	523,311	yes	0
Sunworld	30,835	yes	0
Transamerica	1,311	thru Oct	0
World	44,562	yes	.0102
TOTALS	1,672,426		1.9561
AFQ	1:854,980		

Table 3.12 U. S. Domestic Airlines--New Entrant Jet Carriers

CHAPTER 4
RESULTS

I will now present the results of this study by first addressing the international data and then the U.S. domestic findings. I will wrap up the chapter with a comparison of U.S. domestic to international airline records.

4.1 International Airlines

In this section, I will discuss the results from the 39 airlines of the original BAS study, and follow up with a discussion of the results from the entire international fleet.

4.1.1 International Airlines--BAS Study

First, I considered the international airlines from the BAS study as a group, and computed the AFQs in the form 1 in X. To look at the results from a historical perspective, I have placed the findings from the BAS study side by side with my results in Table 4.1.

One can see remarkable improvement throughout the 27-year period studied and most notably from the mid 1970s to the mid 1980s. These results are significant in both absolute and relative terms. In the 27-year period, the international carriers have seen a nearly tenfold improvement, while the most recent decade has been characterized by a nearly fivefold improvement in

Period	Chance of Being Killed on a Flight
1960-64	1 in 163,000
1965-70	1 in 366,000
1971-75	1 in 340,000
1976-80	1 in 1,094,000
1981-86	1 in 1,523,000

Table 4.1 Chance of Being Killed on a Flight--International Airlines, BAS Study

fatality rate. In relative terms, the fatality risk has dropped 89% over the entire period of study, and 77% over the last ten years alone.

After separating these airlines into groups by traffic level as in the BAS study, one arrives at the results in Table 4.2.

Airline Size	1960-64	1965-70	1971-75	1976-80	1981-86
Large	1: 271,000	1: 512,000	1: 616,000	1: 4,330,000	1: 4,434,000
Small	1: 53,000	1: 168,000	1: 134,000	1: 354,000	1: 563,000

Table 4.2 Chance of Being Killed on a Flight--International Airlines, Grouped by Size, BAS Study

Again, one sees substantial improvement within each group over the entire period, but most particularly from the mid '70s to mid '80s. The large international group enjoyed the greatest improvement in absolute terms, sixteenfold over the entire period of study, and sevenfold over the last decade,

while the small carriers improved by a factor of ten over the entire period and a factor of four in the last ten years.

Examining the difference in improvement between the large and small international airlines in percentage terms, however, shows the large and small carriers to be more alike. The fatality rate for the large internationals dropped 94% over the 27 year period and 86% from the mid '70s to the mid '80s, while the small internationals showed a 91% decrease over the entire period and a 76% decrease in fatality rate in the last decade.

4.1.2 International Airlines--Entire Group

By combining the values for the CFQs and N from Tables 3.9 and 3.10, I arrived at an AFQ of 1:1,007,853 for 76-80, and 1:1,210,574 for 81-86 for the entire group of 122 international airlines. It is interesting to note that although the entire group is responsible for over 50% more traffic than the 39 from the BAS study, the fatality rate is remarkably similar.

I then separated the 122 international airlines into large and small groups based on an average activity level of 20,000 flights per year or more for the large group, and less than that for the small group. The small airlines had an AFQ of approximately 1:460,000 from 1976-80 and 1:718,000 from 1981-86. Their record is rather close to that of the small airlines in the original BAS study. The large airlines, however, provide a little different story.

In the period 1976-80, the entire group of large international carriers had an AFQ of 1:4,066,000 which was quite close to the group from the BAS study. On the other hand, for 1981-86, their AFQ was 1:2,227,000. In trying to

determine whether this apparent downturn in safety is statistically significant, one must consider the volatility of the data being studied. Given the fact that fatal airline crashes are quite rare, chance alone can cause large fluctuations in the AFQs. For example, if one fully fatal crash in the entire group of large internationals were to have occurred in the period 76-80 rather than 81-86, the AFQs would have been 1:2,424,000 for the first period, and 1:3,247,000 for the second. An improvement rather than an apparent decline would have been indicated! This same volatility could easily be responsible for the apparent stagnation in improvement in safety levels in the large internationals of the BAS study from the period 76-80 to the period 81-86.

Finally, I ranked the 122 international airlines from worst to best in terms of AFQs from 1976-86 in Table 4.3. I have noted the industry average for the internationals of the BAS study during the period 1971-75 on the table. In their study, BAS found that "the best airlines tended to be fairly large and/or from technologically advanced countries," with some exceptions [1]. In looking at Table 4.3, one sees a strikingly similar pattern. All of the airlines with poorer observed records than the industry average for the previous period (1971-75), are small airlines. Also, with one exception (Western), they are from countries which are technologically less advanced. One must keep in mind however, that there are many small airlines which maintained a perfect record during the period. Whether these perfect records are attributable to a fine performance in terms of safety or just luck, given the scarcity of flights, would be very difficult to determine.

In general, the dichotomy between the large and small international carriers of the BAS study continued into the recent years and also seems to hold

AIRLINE	N (in thousands)	CFQ	AFQ (as odds)
Cubana	17	2.00	1:8,500
Air India	164	2.17	1:76,500
Avianca (Colombia)	95	0.94	1:101,100
Egyptair	172	1.61	1:106,800
Iraqi Airways	76	0.65	1:116,900
Aeromexico	137	1.00	1:137,000
MEA (Lebanon)	142	1.00	1:142,000
LOT (Poland)	148	1.00	1:148,000
Alia (Jordan)	141	0.86	1:164,000
PIA (Pakistan)	166	1.00	1:166,000
KAL (Rep. of Korea)	191	1.06	1:180,000
Western	158	0.82	1:192,700
Air Lanka	46	0.16	1:287,000
Malev (Hungary)	158	0.47	1:338,500
International Airline AFQ, 1971-75			1:340,000
Gulf Air (Gulf States)	364	1.00	1:364,000
Eastern	438	1.00	1:438,000
Air Canada	442	0.56	1:789,300
JAL (Japan)	385	0.36	1:1,069,400
Iberia (Spain)	733	0.58	1:1,263,800
British Airways	1,456	1.00	1:1,456,000
Indian Airlines	61	0.02	1:3,050,000
TWA	219	0.04	1:5,475,000
Tarom (Romania)	74	0.01	1:7,400,000
THY (Turkey)	83	0.01	1:8,300,000
Swissair	892	0.10	1:8,920,000

Table 4.3 Worst to Best Listing of International Airlines--Entire Group

AIRLINE	N (in thousands)	CFQ	AFQ (as odds)
Pan Am	794	0.04	1:19,850,000
Saudia	223	0.01	1:22,300,000
El Al	107	0.003	1:35,666,700
Air France	1,345	0.01	1:134,500,000
All remaining airlines have a CFQ of 0.			

Table 4.3 Worst to Best Listing of International Airlines--Entire Group

true for the entire fleet of international airlines. One cannot, and should not say that, merely because an international airline is small, it is less safe than the large ones. Certainly the 25-year accident free records of Qantas and Finnair provide no motivation for saying so. Nevertheless, one cannot deny that as a group, the small international airlines' safety record is considerably poorer than that of the larger international carriers. It has been argued that the small carriers are at a disadvantage because a single crash has a more profound effect on their safety records [7]. But this assertion misses the point that the "disadvantage" is balanced by a corresponding drop in the number of opportunities to have an accident.

I would like to turn my attention now to the U.S. domestic scene.

4.2 U.S. Domestic Airlines

I will first examine the results from the airlines of the original study and then I will take a hard look at the "children of deregulation."

4.2.1 U.S. Domestic Airlines--BAS Study

Again, I will put my results together with those of the original study in Table 4.4.

As with the international fleet, the U.S. domestic airlines have shown a marked improvement over the entire (in this case, 30 year) period, with the most notable change happening in the last 10 years.

Period	Chance of Being Killed on a Flight
1957-61	1 in 988,000
1962-66	1 in 1,087,000
1967-71	1 in 2,064,000
1972-76	1 in 2,599,000
1977-81	1 in 11,018,000
1982-86	1 in 10,157,000

Table 4.4 Chance of Being Killed on a Flight--U.S. Domestic Airlines, BAS Study

In absolute terms, one can see a tenfold improvement over the entire period, and a fourfold improvement in the last ten years. This becomes a 90% drop in fatality rate over the 30-year period, and a 74 % drop in the most recent decade. When one considers that the U.S. domestic airlines started the period of study with the most favorable AFQ (three times better than the nearest competitor), these percentage improvements are all the more impressive. One could attribute the apparent level off in the rate of improvement from the second to the last period to chance fluctuations as I explained with the large international carriers.

Since the last two periods (77-81 and 82-86) include the post-deregulation period, it would certainly seem that deregulation has not had a detrimental effect on the well-established trunk carriers. The record isn't nearly as favorable, however, for the new entrant jet carriers.

4.2.2 New Entrant Jet Carriers

It is interesting to contrast the established trunk carriers' AFQ of 1:10,600,000 during 1977-86 with the record of the new entrant jet carriers, born of deregulation. As one can see in Table 3.10, the new entrant jet carriers have earned an unenviable AFQ of 1:854,980 over their brief lifetimes. Their record is clearly somewhat worse than that of the established U.S. domestic airlines. In fact, it is worse than the other U.S. domestics by a factor of 12. It would seem that the new entrant jet carriers' record has more in common with the worst group (small internationals--1:718,000) than with the U.S. domestics with whom they share a working environment. Again, one should evaluate whether the difference between the records of the new entrant jet carriers and the established U.S. domestics could be explained by random fluctuations alone. As I have noted before, the data is quite volatile, but even removing a fully fatal crash from the period in question would only improve the new entrants' AFQ to 1:1,749,217, still six times less safe than the established carriers.

I would now like to look at how likely the new entrants' safety record would be if they were as safe as the U.S. domestic airlines which were established before deregulation. To do this, one needs the AFQ for the established U.S. domestics (1:10,600,000), and the number of flights of the new entrants, let's call it M (= 1,672,000).

In their analysis [1], BAS pointed out that the AFQ is approximately equal to the probability that any given flight will experience a major crash (i.e., a crash with few, if any, survivors). They also stated that, under the equal safety

hypothesis, an airline's CFQ should be roughly Poisson distributed with mean equal to, in this case

$$M \times AFQ\,(group) = (1{,}672{,}000) \times (\frac{1}{10{,}600{,}000}) = .158$$

So, the probability of k_0 major crashes is roughly equal to

$$p_k(k_0) = \frac{(.158)^{k_0} e^{-.158}}{k_0!}, \quad k_0 = 0,1,2,\ldots$$

The chance of zero major crashes in the approximately 1,657,000 flights flown by the new entrants was

$$p_r(k_0) = e^{-.158} = .854$$

The chance of one or fewer major crashes was

$$\sum_{k_0=0}^{1} p_k(k_0) = e^{-.158} + (.158)e^{-.158} = .989$$

This means that the actual event which did occur (the equivalent of at least two major crashes) had only about one percent chance of occurring if the new entrant jet carriers were as safe as the established U.S. domestics. Indeed, if the Arrow Air crash of December 1985 had not been excluded because the flight was a military charter, the computed chance that the new entrants were as safe as the established domestics would be approximately one tenth of one percent!

Looking at individual carrier records, Midwest Express, with an AFQ of 1:11,435, is second only to Cubana on the worst to best listing on Table 4.3. Air Florida, with an AFQ of 1:190,597, is in a position roughly equivalent to the 11th worst international carrier. Seeing that these two airlines are almost

solely responsible for the poor record of the new entrants makes one wonder if any conclusion can be made about the group on the whole. Certainly, People Express, New York Air and Midway Airlines have maintained a perfect record while flying a high volume of traffic. Actually, with the limitations that these sparse data impose, one cannot determine whether the group of new entrants is homogeneous with respect to their safety behavior.

Then what can one say about the impact (if any) of deregulation on safety? As I had mentioned in Chapter Two, the government has ordered continuing safety studies since deregulation, partially because they were concerned about a shrinking FAA inspector force handling a rapidly growing number of air carriers. These studies have always shown an improvement in airline safety in the U.S. since deregulation. In fact, the U.S. improvement in airline safety over the last two periods studied has been so dramatic, that when you average in the data for the (relatively small) new entrant jet carriers, it has little effect on the apparently improved safety levels. I have shown in this study, however, that when the new entrants are considered as a separate group, one sees a very different story. Rather than appearing as the best in terms of safety records as do the more established airlines which operate in the very same system, they have a record in competition with the worst airlines as a group. It would seem that the positive performance of the established carriers in the U.S. has masked the relatively poor safety performance of the "children of deregulation."

4.3 Comparison of U.S. Domestic Airlines with International Airlines

The original study cites that overall, the U.S. domestic airlines were safer (in terms of fatality rate) by a factor of four than the large internationals which were, in turn, four times safer than the small internationals [1].

I tested the hypothesis that the ratio of fatality rates of the U.S. domestic carriers to those of the large international airlines were equal to four over the entire period. I performed the same test on the ratio of the large international fatality rates to those of the small international airlines. Although the periods studied for the U.S. domestics did not precisely coincide with those of the internationals, there is sufficient overlap to provide a basis for comparison.

The lack of a distinct trend (increasing or decreasing) in the ratios obtained tended to support the nomality assumption required for the one sample *t*-test. Strictly speaking, the ratios are not normal random variables, but the probabilistic behavior of the *t* ratio is often only minimally affected by the nonnormality of the population being sampled. [3].

When I tested these ratios over the period of both studies using a one-sample *t*-test, I found both of them to be essentially constant at four at any usual significance level (.05, .10, and .01).

CHAPTER 5

CONCLUSIONS AND EXTENSIONS

5.1 Conclusions

An important consideration in analyzing the results of this study is the fact that (fortunately) the data are so sparse. While it may be difficult to draw hard and fast conclusions, the consistent trends offer compelling evidence of a continuing, statistically significant improvement in airline safety overall since the beginning of the jet age.

Specifically, this study has led me to conclude that:

1) In the past quarter of a century, all major segments of the airline industry have experienced a nearly 90% drop in fatality rate.

2) This continuing improvement has been most marked in the last decade with a minimum of 74% improvement in all groups.

3) The dichotomy in safety levels between the small and large international carriers, with the small internationals lagging behind their larger counterparts by a factor of approximately four, has continued throughout the entire 25-year period studied. The results from the entire international fleet of 122 airlines for the past ten years were consistent with the results from the 40 selected carriers studied over the 25-year period.

4) The extraordinary improvement by the safest segment studied (the established U.S. domestics) seems to have masked the negative impact of the poor safety record of the "children" of deregulation. In fact, the U. S. domestic airlines are still safer than the large international airlines by around a factor of four.

5.2 Extensions

It would certainly be interesting to follow the safety records of the new entrant jet carriers through another five year period or two, but that will probably not be possible. There has been a process of attrition among the new entrants, Air Florida, Arrow Air, and People Express to name a few. As a case in point, Continental has plans to absorb New York Air and People Express by February 1, 1987. It would seem that the new entrants were a transient phenomenon. Given that their presence did not visibly harm the safety records of the major U.S. carriers, we can be hopeful that the new entrants will exert no "residual harm" after they disappear.

The other aspect for future study would be to see if the essentially constant improvement trend continues in each major division of airlines studied here. Some authors suggest that there is a limiting effect, putting a ceiling on the level of airline safety attainable. One would think that if that were the case, the most progressive airlines in terms of safety would reach that ceiling first, namely the long established U. S. domestic airline. It will also be interesting to see if the U. S. airlines maintain their relative position with respect to the large

and small international airlines.

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APPENDIX

Table A.1 Number of Flights (Departures) for Formerly Intrastate Carriers, 1977-1981

Airline	1977*	1978	1979	1980	1981
Air Cal	39,364	DNR	44,410	46,977	57,171
Air Florida	6,620	DNR	20,822	36,404	48,318
PSA	77,012	DNR	90,417	70,068	75,076
Southwest	29,245	DNR	70,818	91,143	140,029

*1977 Data were extracted from June 1, 1977 Official Airline Guide, North American Edition. They assume 100% completion of scheduled flights

DNR = Data Not Reported

1979-1981 Data were extracted from Table A.6

AIRLINE	1976	1977	1978	1979	1980
Aer Lingus	24,593	24,326	24,904	24,497	25,618
Aerolin Dominicanas (Dominican Republic)	640*	640*	640*	640†	640
Aerolineas Argentina	14,797	15,557	17,417	18,412	20,995
Aeromexico	11,061	9,813	10,253†	10,692	13,083†
Aeroperu	3,483	2,994	3,827	3,881	3,222
Air Afrique (Yaounde Treaty States)	12,688	11,546	11,299	11,599	11,180
Air Canada	42,365	38,402	40,208	43,363	46,161
Air France	121,728	129,951	138,737	136,851	124,169
Air India	13,953	15,543	15,170	14,929	15,867
Air Jamaica	7,739	7,129	7,631	8,842	8,371
Air Lanka	3,090	3,939	1,877	1,219	3,503
Air Madagascar	1,836	1,753	1,839	1,349	1,105
Air Malawi	1,699	1,734	2,000	1,512	1,367
Air Malta	2,430	2,522	3,366	3,629	4,338
Air Mauritius	1,034*	1,034	2,223†	3,412	4,484
Air New Zealand	7,710	7,163	7,475	7,544	8,256
Air Niugini (Papua New Guinea)	1,464	1,492	1,535	1,867	1,962
Air Panama	3,728	3,240	3,001	2,991	2,892
Air UK	17,892†	20,788†	23,497	31,296†	24,722
Air Zaire	2,938	2,779	2,280	2,064†	1,848†
Alia (Jordan)	8,272	8,912	9,892	11,328	13,358

Table A.2 Traffic Data for International Airlines 1976-1980
†estimated from partial data, *estimated from adjacent years

AIRLINE	1976	1977	1978	1979	1980
Alisarda (Italy)	284	192	282	330	341
Alitalia	69,752	70,967	69,474	57,592	61,225
ALM (Netherlands Antilles)	3,060	4,937	4,614*	4,614*	4,291†
American	23,174	26,846	28,569	29,748	30,682
ARCO (Uruguay)	1,512	1,512	1,556	1,935†	2,314
Ariana (Afghanistan)	2,148	2,547	2,373	2,395	1,459
AUA (Austria)	22,146	23,077	25,006	25,270	26,330
Avianca (Colombia)	8,446	7,865	8,189	8,594	9,182
Aviateca (Guatemala)	4,541	4,954	4,361	4,259	3,216
Bangladesh-Biman	2,301	2,577	2,907	3,533	3,414
British Airways	131,966	130,054	141,725	149,871	146,184
British Caledonian	18,946	18,206	20,607	21,543	23,498
British Midland	3,563	3,783	4,669	3,931	3,120
BWIA (Trinidad Tobago)	8,054	10,574	6,061	10,357	12,289
Cameroon	2,064*	2,064	1,400	1,644*	1,888
Caribbean (Barbados)	467	574	648	586	304†
Cathay Pacific (Hong Kong)	17,035	17,677	19,264	20,507	19,874

Table A.2 Traffic Data for International Airlines 1976-1980
†estimated from partial data, *estimated from adjacent years

AIRLINE	1976	1977	1978	1979	1980
CDA (Dominicana-Dominican Republic)	2,924	3,696	4,130	4,616†	4,616†
COPA (Panama)	3,586	3,556	3,595	4,220	3,768
CP Air (Canada)	10,812	8,856	8,534	8,346	8,670
Cruzeiro (Brazil)	3,905	3,915	4,339	5,187	5,312
CSA (Czechoslova-kia)	12,333	12,462	12,722	13,163	12,203
Cubana	1,106	1,077	1,226	2,072	1,841†
Cyprus	4,699	5,231	5,206	5,444	6,248
Dan-Air (UK)	4,621	5,833	6,239	7,855	7,780
Delta	8,484	8,526	9,607	9,017	8,874
Eastern	38,881	34,604	35,090	38,723	35,855
Ecuatoriana (Ecuador)	2,651	3,958	4,661	5,573	5,938
Egyptair	11,150	13,239	12,629	13,963	15,688
Ethiopian	6,597	6,567	5,962	6,081	5,967
El Al	9,213	10,117	9,689	9,861	8,973
Faucett (Peru)	276	414	650	574	472
Finnair	21,903	21,074	22,052	22,927	24,069
Frontier	1,427	1,438	1,619	3,753	5,467
Garuda (Indonesia)	9,214	10,486	11,626	12,982	15,118
Ghanair	3,100	3,071	3,418	2,956†	2,956†
Gulf Air (Gulf States)	24,617	25,285	28,602	33,299*	33,299*
Iberia (Spain)	62,148	62,793	64,049	68,428	69,191

Table A.2 Traffic Data for International Airlines 1976-1980
†estimated from partial data, *estimated from adjacent years

AIRLINE	1976	1977	1978	1979	1980
Icelandair	4,862	4,985	5,435	5,170	3,656
Indian Airlines	4,135	5,311	5,447	5,553	5,480
Iran Air	12,578	13,489	13,489	5,539	4,046
Iraqi Airways	6,253	7,737	8,087	8,544	6,717
JAT (Yugoslavia)	22,237	21,624	22,017	20,365†	20,365*
JAL (Japan)	28,120	30,056	33,256	36,347	37,381
Japan Asia Airways	2,416	3,797	3,806	3,886	4,437
KLM	56,977	58,395	66,850	66,665	65,192
KAL (Rep. of Korea)	12,277	12,966	14,754	16,452	21,834
Kuwait Airways	9,740	11,600	12,474	12,544	12,892
LAB (Bolivia)	2,107	2,816	3,178	3,975	3,684
LACSA (Costa Rica)	6,119	6,465	6,905	7,823	7,955†
LADECO (Chile)	128	278	357	428	969
Lan Chile	6,349	6,466	5,998	5,564	6,129
LAV (Venezuela)	1,539	1,683	1,734	3,494	3,668
Libyan Arab	3,993	4,308	4,633	4,810*	4,986
LOT (Poland)	14,008	15,264	16,781	17,823	17,782
Lufthansa	98,931	99,598	100,308	101,988	106,684
Malev (Hungary)	4,308	8,998†	13,688	15,451	15,566
MAS (Malaysia)	13,978	14,958	15,456	16,031	18,392
MEA (Lebanon)	12,537*	12,537	13,303	13,021	13,640

Table A.2 Traffic Data for International Airlines 1976-1980
†estimated from partial data, *estimated from adjacent years

AIRLINE	1976	1977	1978	1979	1980
Merpati Nusantara (Indonesia)	524	522	684	562	259
Mexicana	11,366	12,231	14,426†	16,621	18,457
NLM (Netherlands)	10,901	10,187	6,163	7,546	12,434
Nigeria Airways	4,180	4,422	4,561	5,512	7,298
Nordair (Canada)	981*	981	1,048	1,082	2,415
Northwest	12,279	12,147	7,329	13,203	14,380
Olympic	16,828	16,242	17,384	16,420	13,490
Pacific Western (Canada)	3,063	2,939	2,951	3,441	3,854
PAL (Philippines)	5,834	4,580	5,435	7,193*	8,951
Pan Am	81,910	78,966	73,523	72,701	66,657
PIA (Pakistan)	11,709	13,647	15,835	16,469	16,669
Pluna (Uruguay)	6,546	5,817	6,258†	6,698	5,622*
Qantas	18,835	17,345	16,254	15,426	15,651
Republic	13,444	15,008	13,949	14,014	15,524
Royal Air Maroc (Morocco)	17,240	17,105†	16,970	16,095	14,041
Royal Nepal	1,784	2,295*	2,295*	2,806	2,705
SAA (South Africa)	10,843	10,912	11,611	11,975	11,885
Sabena	39,888	42,842	45,978	48,012	47,767
SAHSA (Honduras)	5,902	5,533	6,117	6,123	8,983

Table A.2 Traffic Data for International Airlines 1976-1980
†estimated from partial data, *estimated from adjacent years

AIRLINE	1976	1977	1978	1979	1980
SAM (Colombia)	1,400	1,027	927	783	882
SAS	93,122	92,196	95,755	99,308	94,465
Saudia	12,890	15,456	17,414	19,277	21,278
SIA (Singapore)	25,724	27,486	30,254	32,833	32,466
Swissair	85,528	86,550	88,163	89,249	91,082
Syrian Arab	7,441	7,444†	7,447	6,857*	6,266
TAAG-Angola	436	518	1022*	1022*	1022*
TAC (Thailand)	1,200	858	1,092	1,290	1,258†
TACA (El Salvador)	11,982*	11,982	11,850	8,683	8,078
TAN (Honduras)	2,765	2,679	2,963	3,397	3,548
TAP Air Portugal	10,869	10,688	11,772	12,664	12,795
Tarom (Romania)	7,650	10,323	8,195	8,430	9,348
Thai Int'l	12,419	12,585	13,868	14,786	16,368†
THY (Turkey)	7,421	7,091	7,064	7,158*	7,158*
Tunis Air	9,789	9,626	10,197	11,103	11,321†
TWA	24,750	23,761	23,745	23,002	17,728
United	5,696	4,706	5,089	3,980	4,183
US Air	13,143	12,250	11,779	10,571	9,876
UTA (France)	14,703	16,588	16,357	15,382	13,980
Varig (Brazil)	3,905	3,915	4,339	5,187	5,312
Viasa (Venezuela)	9,541	9,962	10,220	10,486	10,633
Western	12,956	14,012	15,054	15,117	14,450

Table A.2 Traffic Data for International Airlines 1976-1980
†estimated from partial data, *estimated from adjacent years

AIRLINE	1976	1977	1978	1979	1980
Zambia Airways	2,148	2,584	2,696	2,447*	2,198

Table A.2 Traffic Data for International Airlines 1976-1980
†estimated from partial data, *estimated from adjacent years

AIRLINE	1981	1982	1983	1984	1985
Aer Lingus	25,124	24,413	24,864	27,793	30,046
Aerolin Dominicanas (Dominican Republic)	4,616†	5,102	5,607	6,346	6,228†
Aerolineas Argentina	17,272	14,275	12,507	11,960	13,683†
Aeromexico	14,219	12,630	9,024	16,054	15,057
Aeroperu	2,673	2,951	3,655	3,635	3,468
Air Afrique (Yaounde Treaty States)	10,872†	11,415	10,874	10,275	11,226
Air Canada	43,778	36,194	35,264	37,872	39,153
Air France	116,706	111,059	114,421	116,074	117,693
Air India	14,244	14,483	15,046	15,356	14,503
Air Jamaica	7,706	8,076	6,772	5,059	4,316
Air Lanka	4,061	3,450	5,414	5,941	6,744
Air Madagascar	975	940	919	963	1018
Air Malawi	1,623	2,052	2,133†	2,281	2,464
Air Malta	4,588	4,843	4,350	4,019	4,044
Air Mauritius	4,253	4,606	4,985	5,579	6,038†
Air New Zealand	8,074	6,641	6,465	6,217	6,734
Air Niugini (Papua New Guinea)	2,064	2,004	1,628	1,808	1,402†
Air Panama	2,623	2,704	2,779†	2,906	2,879
Air UK	20,170	18,853	18,772	17,748	23,448
Air Zaire	1,751†	1,654†	1,654*	1,654*	1,654*
Alia (Jordan)	15,724	14,950*	14,950*	14,950*	14,176

Table A.3 Traffic Data for International Airlines 1981-1985
†estimated from partial data, *estimated from adjacent years

AIRLINE	1981	1982	1983	1984	1985
Alisarda (Italy)	245	358	338	425	366
Alitalia	52,337	52,388	51,263	53,292	55,311
ALM (Netherlands Antilles)	4,517	5,266	4,804†	4,804*	4,804*
American	27,166	31,754	29,645†	31,245	30,436
ARCO (Uruguay)	2,295*	2,275†	1,338	1,588	1,484
Ariana (Afghanistan)	1,207	1,136	1,136*	1,136*	1,136*
AUA (Austria)	27,022	26,987	27,063	27,336	27,257
Avianca (Colombia)	10,196	9,203	8,677	8,998	7,922
Aviateca (Guatemala)	3,080	3,102	2,042	1,519	1,663†
Bangladesh-Biman	3,709*	3,709*	3,709*	4,004	5,531
British Airways	132,725	123,257	117,821	121,441	130,305
British Caledonian	22,914	22,117	22,544	23,143	21,873
British Midland	2,159	3,680	3,982	3,481	3,035
BWIA (Trinidad Tobago)	11,505*	10,720†	10,479	10,479*	10,479*
Cameroon	1,730*	1,571	1,483	1,483*	1,483*
Caribbean (Barbados)	367	209†	264	540†	528
Cathay Pacific (Hong Kong)	19,588	19,859	19,569	21,774	21,675

Table A.3 Traffic Data for International Airlines 1981-1985
†estimated from partial data, *estimated from adjacent years

AIRLINE	1981	1982	1983	1984	1985
CDA (Dominicana-Domincan Republic)	4,616†	5,102	5,607	6,346	6,228†
COPA (Panama)	3,622	3,534†	3,990	3,922	4,051
CP Air (Canada)	8,352	8,132	7,997	9,564	9,820
Cruzeiro (Brazil)	3,727	3,200	3,404	3,921	3,782
CSA (Czechoslova-kia)	12,870	12,089	12,475	12,720	13,591
Cubana	1,678†	1,678*	1,678*	1,678*	1,678*
Cyprus	5,744	5,682	5,861	6,193	6,092
Dan-Air (UK)	7,020	7,420	8,328	10,815	12,992
Delta	9,290	8,870	8,198	8,650	10,197
Eastern	38,151	42,152	44,638	44,342	43,058
Ecuatoriana (Ecuador)	5,618*	5,298	4,461	4,598	4,180†
Egyptair	16,045	16,913†	18,129	17,640	18,185
Ethiopian	7,344†	6,543†	6,543*	6,543*	6,543*
El Al	8,989	8,306	8,197	10,480	11,624
Faucett (Peru)	762	644	760	536	666
Finnair	25,396	24,440	23,855	23,453	24,134
Frontier	6,150	6,389	5,403	5,485	4,640
Garuda (Indonesia)	15,306†	14,374	12,954	11,562	12,247
Ghanair	2,494	2,132†	2,132*	2,132*	2,132*
Gulf Air (Gulf States)	33,299*	33,299*	37,995	37,995*	37,995*
Iberia (Spain)	66,334	67,107	66,669	69,161	68,784

Table A.3 Traffic Data for International Airlines 1981-1985
†estimated from partial data, *estimated from adjacent years

AIRLINE	1981	1982	1983	1984	1985
Icelandair	3,251	4,057	4,402	4,866	5,458
Indian Airlines	5,739	5,958	6,031	5,742	5,983
Iran Air	1,859	2,516	3,390	4,121	5,781
Iraqi Airways	6,628†	6,539	6,414†	6,414*	6,414*
JAT (Yugoslavia)	20,365*	18,712	16,851*	14,990†	15,490
JAL (Japan)	36,792	36,604	35,152	35,979	37,654
Japan Asia Airways	4,225	4,270	4,112	4,281	4,367
KLM	62,564	61,688	62,939	62,116	62,648
KAL (Rep. of Korea)	19,902	20,346	19,975	20,954	15,604†
Kuwait Airways	13,367	13,313	14,598	14,719	14,151
LAB (Bolivia)	3,716	3,165	2,898	3,591	3,778†
LACSA (Costa Rica)	7,008	6,876	5,987	5,552	5,405
LADECO (Chile)	1,236	1,336	1,395†	1,919†	1,919*
Lan Chile	6,007	4,458	3,565†	3,555†	3,555*
LAV (Venezuela)	3,822	3,650	2,820	2,618	1,962
Libyan Arab	5,557	5,999*	6,441	7,026	7,026*
LOT (Poland)	15,668	4,965	8,681	10,902	12,956
Lufthansa	106,654	108,872	113,892	114,994	121,022
Malev (Hungary)	16,094†	16,621	15,699	17,018	17,197
MAS (Malaysia)	19,003†	19,040	19,664	20,017	29,382†
MEA (Lebanon)	12,429	12,852†	12,852*	12,852*	12,852*

Table A.3 Traffic Data for International Airlines 1981-1985
†estimated from partial data, *estimated from adjacent years

AIRLINE	1981	1982	1983	1984	1985
Merpati Nusantara (Indonesia)	102	134	92	104	102
Mexicana	21,028	17,672	17,922	11,627	12,239
NLM (Netherlands)	13,458	14,317	12,529	11,909	11,984
Nigeria Airways	8,524	5,975	6,451	5,928	5,928*
Nordair (Canada)	3,351	1,526	1,806	1,925†	2,935†
Northwest	14,866	15,033	16,550	18,434	19,267
Olympic	14,098	14,009	14,698	20,014	21,285
Pacific Western (Canada)	3,534	2,638	1,865	828	921
PAL (Philippines)	8,975†	8,998†	10,618	9,801†	10,011†
Pan Am	65,152	67,255	69,049	72,296	73,125
PIA (Pakistan)	15,826	14,646	14,835	15,093	15,534
Pluna (Uruguay)	5,622†	4,545†	4,327	3,987	3,704
Qantas	15,616	18,050	16,927	17,283	17,721
Republic	13,152	12,309	10,871	8,571	8,633
Royal Air Maroc (Morocco)	16,376	15,708	16,892	12,401	9,742
Royal Nepal	2,864	3,068	2,839	2,912	4,051†
SAA (South Africa)	11,992	11,728	10,228	9,492	9,089
Sabena	43,020	40,422	39,071	40,360	43,181
SAHSA (Honduras)	6,604	6,534	5,981	5,175	5,300†

Table A.3 Traffic Data for International Airlines 1981-1985
†estimated from partial data, *estimated from adjacent years

AIRLINE	1981	1982	1983	1984	1985
SAM (Colombia)	818	835	931	932	1,014
SAS	90,447	89,568	94,770	98,025	102,739
SIA (Singapore)	29,917	29,879	34,621	29,838	31,143
Swissair	78,935	77,276	74,761	72,359	73,995†
Syrian Arab	7,306	7,289	6,100†	6,100*	6,100*
TAAG-Angola	1,525	1,520†	1,852*	1,852*	2,184†
TAC (Thailand)	1,376	1,965	2,167	2,133	2,103†
TACA (El Salvador)	8,124	9,041	8,257	9,171†	9,624†
TAN (Honduras)	3,469	2,724	2,717	3,019	3,338†
TAPAir Portugal	13,125	13,191	12,783	12,430	12,214
Tarom (Romania)	5,200	4,878	4,650	5,056	5,194
Thai Int'l	17,660	18,730	18,733	19,755	21,028†
THY (Turkey)	7,158*	7,158*	7,252	8,627	8,627*
Tunis Air	12,125	12,265	12,066	12,223	12,217
TWA	14,168	13,140	14,619	18,629	22,581
United	5,000	7,000	9,000	11,000	10,000
US Air	9,860	11,788	13,024	12,957	14,483
UTA (France)	12,876	12,092	11,538	8,938	8,892
Varig (Brazil)	11,441	11,627	11,028	11,828	11,573
Viasa (Venezuela)	10,296†	10,563	9,953	9,953*	9,953*
Western	15,558	13,021	15,876	14,882	13,770
Zambia Airways	1,707	2,126	2,121	2,138	1,827

Table A.3 Traffic Data for International Airlines 1981-1985
†estimated from partial data, *estimated from adjacent years

AIRLINE	1977	1978	1979	1980	1981
American	354,945	358,295	352,775	311,622	276,267
Braniff	189,670	206,375	228,997	177,487	143,470
Continental	142,890	150,507	156,163	133,149	116,958
Delta	507,485	531,745	540,041	527,157	508,165
Eastern	512,099	531,270	538,694	519,113	485,187
Frontier	189,608	198,699	207,381	182,484	169,487
Republic (from Hughes North Central & Southern)	495,647	527,803	500,054	520,108	464,314
Pan Am (including National)	137,605	123,023	109,502	105,843	76,535
Northwest	162,477	91,925	155,406	157,484	149,455
Ozark	153,753	157,792	123,871	117,441	112,611
Piedmont	175,060	168,970	168,581*	168,191	180,419
Texas Int'l	90,029	91,798	89,280	89,398	76,241
TWA	275,993	271,602	273,454	237,218	199,123
United	529,891	567,560	465,663	461,683	372,000
US Air (Allegheny)	292,140	294,631	277,606	273,754	261,683
Western	147,703	149,965	153,798	127,314	111,043

Table A.4 Traffic Data for U.S. Domestic Airlines 1977-1981
*estimated from adjacent years

AIRLINE	1982	1983	1984	1985
American	286,399	319,339†	368,847	430,494
Braniff	50,565	service suspended	34,388	17,639
Continental	136,650	158,554	134,295	185,673
Delta	484,361	501,194	511,166	526,283
Eastern	458,621	469,404	493,653	513,431
Frontier	135,031	133,438	134,850	123,567
Republic	447,716	440,721	397,899	357,360
Pan Am	69,204	71,447	69,861	51,396
Northwest	137,313	151,239	149,966	161,780
Ozark	104,293	110,187	110,003†	113,936
Piedmont	187,966	227,546	269,847	322,328
Texas Int'l	merged with Continental			
TWA	181,721	180,577	189,485	200,957¤
United	393,000	445,000	526,000	472,000
US Air (Allegheny)	279,736	301,058	319,448	337,160
Western	126,094	147,077	141,129	154,500

Table A.5 Traffic Data for U.S. Domestic Airlines 1982-1985
†estimated from partial data, ¤ obtained from CAB statistics

AIRLINE	1979	1980	1981	1982	1983	1984	1985
Air Florida	**20,822**	**36,404**	48,318	36,220	29,875	8,647	--------
Air One						**6,005**	--------
America West					**5,744**	43,030	47,112
Arrow Air				**718**	2,417	**2,795**	3,246
Capitol		231	3,494	6,208	5,108	5,184	-------
Florida Express						**9,082**	18,347
Jet America				**2,404**	**4,065**	7,065	7,047
Midway Metrolink		9,910	14,726	22,592	23,678	22,028	48,501
Midwest Express						**2,033**	**4,701**
Muse Air			3,171	**14,118**	23,021	35,386	38,054
New York Air		216	21,753	29,928	31,587	38,233	55,320
Northeastern Int'l Airways				**1,148**	6,474	51,839	616
Pacific East Air				76	**1,318**	357	--------
People Express			14,862	37,490	**74,941**	110350	142834
Sunworld Int'l					**337**	7,966	11,266
Transamerica		12	8	74	251	341	341
World		**3,406**	6,781	6,137	4,426	7,430	8,191

Table A.6 Traffic Data for U.S. Domestic Airlines--New Jet Entrants
bold type indicates CAB statistics, underlining indicates estimate

Table A.7 1976 Accidents

Date	Airline	Int'l or Domestic	Explanation
1 Jan	MEA	Int'l	Occurred in Saudi Arabia
19 Mar	Cubana	Domestic	Training flight-crew only
5 Apr	Alaska Airlines	Domestic	Domestic Airline
27 Apr	American	Domestic	New York to U.S. Virgin Islands
21 May	PAL	Domestic	Domestic service only from Davao (departure point)
27 Jun	MEA	Int'l	Crew only
4 Jul	Air France	Int'l	Flight from Tel Aviv to Athens
28 Jul	CSA	Domestic	Flight From Bratislava to Prague, Czechoslovakia
30 Aug	Air France	Int'l	Hijacker was the only fatality
10 Sep	British Airways	Int'l	Occurred over Zagreb, Yugoslavia
20 Sep	THY	Domestic	Istanbul to Antalya, Turkey
6 Oct	Cubana	Int'l	Occurred in Barbados
12 Oct	Indian Airlines	Domestic	Flight from Bombay to Madras, India
23 Nov	Olympic	Domestic	Scheduled to land at Larissa--domestic service only
25 Dec	Egyptair	Int'l	Occurred in Bangkok, Thailand
31 Dec	Faucett	Domestic	Trujillo to Tarapoto, Peru

Table A.7 1977 Accidents

Date	Airline	Int'l or Domestic	Explanation
30 Mar	Merpati Nusantara	Domestic	Flight from Palu to Totitoli, Indonesia
4 Apr	Southern	Domestic	Huntsville to Atlanta
22 Jul	Ethiopian Airlines	Domestic	Teppi to Jimma, Ethiopia
22 Sep	Malev	Int'l	Occurred in Bucharest, Romania
28 Sep	JAL	Int'l	Occurred in Kuala Selangor, Malaysia
17 Oct	Lufthansa	Int'l	Only fatalities were hijacker and crew
3 Nov	El Al	Int'l	Occurred over Belgrade
19 Nov	TAP	Domestic	Flight from Lisbon to Madeira Islands, Portugal
4 Dec	MAS	Domestic	Penang to Kuala Lumpur

Table A.7 1978 Accidents

Date	Airline	Int'l or Domestic	Explanation
1 Jan	Air India	Int'l	Enroute to Dubai in Middle East
11 Feb	Pacific Western	Domestic	Calgary to Cranbrook, B.C.
1 Mar	Continental	Domestic	Los Angeles to Honolulu
1 Mar	Nigeria	Domestic	Sokoto to Lagos, Nigeria
3 Mar	LAV	Domestic	Caracas to Cumana, Venezuela
21 Apr	KAL	Int'l	Occurred in Kem, USSR
8 May	National	Domestic	Mobile to Pensacola
26 Jun	Air Canada	Domestic	Toronto to Winnipeg, Canada
18 Aug	PAL	Domestic	Cebu City to Manila, P.I.
23 Dec	Alitalia	Domestic	Rome to Palermo, Sicily
28 Dec	United	Domestic	New York to Portland

Table A.7 1979 Accidents

Date	Airline	Int'l or Domestic	Explanation
12 Feb	Allegheny	Domestic	Clarksburg to Washington
14 Mar	Alia	Int'l	Amman to Doha, Qatar
25 May	American	Domestic	Chicago to Los Angeles
11 Jul	Garuda	Domestic	Domestic flight
4 Aug	Indian Airlines	Domestic	Poonato to Panvel AP, Bombay
7 Oct	Swissair	Int'l	Occurred in Athens
31 Oct	Western	Int'l	Occurred in Mexico City
26 Nov	PIA	Int'l	Jeddah, Saudi Arabia to Karachi, Pakistan
23 Dec	THY	Domestic	Domestic flight

Table A.7 1980 Accidents

Date	Airline	Int'l or Domestic	Explanation
21 Jan	Iran Air	Domestic	Domestic flight
3 Mar	LOT	Int'l	New York to Warsaw
27 Apr	Thai Airways	Domestic	Udon to Bangkok, Thailand
10 May	Indian Airlines	Int'l	Bagdogra, East Pakistan to Calcutta, India
7 Jul	Tarom	Int'l	Occurred in Nouadhibou, Mauritania
19 Aug	Saudia	Domestic	Riyadh to Jeddah, Saudi Arabia
14 Oct	THY	Int'l	Munich to Ankara
19 Nov	KAL	Int'l	Los Angeles to Alaska to Seoul
23 Dec	Saudia	Int'l	Dhahran to Karachi, Pakistan

Table A.7 1981 Accidents

Date	Airline	Int'l or Domestic	Explanation
26 Mar	LOT	Domestic	Warsaw to Slupsk, Poland
27 Jul	Aeromexico	Domestic	Monterrey to Chihuahua, Mexico
20 Sep	World	Int'l	Crewmember was the only fatality
7 Oct	NLM	Domestic	Rotterdam to Eindhoven
30 Oct	Cameroon	Domestic	Domestic flight
8 Nov	Aeromexico	Domestic	Acapulco to Guadalajara, Mexico

Table A.7 1982 Accidents

Date	Airline	Int'l or Domestic	Explanation
13 Jan	Air Florida	Domestic	Washington to Tampa
23 Jan	World Airways	Domestic	Newark to Boston
25 Jan	Tarom	Domestic	Training flight
9 Feb	JAL	Domestic	Fukuoka, Kyushu to Haneda AP
20 Mar	Garuda	Domestic	Jakarta to Tanjunkarang, Indonesia
22 Jun	Air India	Int'l	International flight
9 Jul	Pan Am	Domestic	Miami to Las Vegas
11 Jul	PAL	Domestic	Jolo AP serves domestic routes only for PAL

Table A.7 1983 Accidents

Date	Airline	Int'l or Domestic	Explanation
9 Jan	Republic	Domestic	Minneapolis to Brainerd, MN
16 Jan	THY	Domestic	Istanbul to Ankara, Turkey
2 Jan	Garuda	Domestic	Tanjunkarang to Jakarta, Indonesia
3 Jun	Air Canada	Int'l	Occurred in Florence, Kentucky
31 Aug	KAL	Int'l	Shot down over Sea of Japan near Sakhalin, USSR
23 Sep	Gulf Air	Int'l	Karachi, Pakistan to Abu Dhabi, United Arab Emirates
8 Nov	TAAG	Domestic	Lubango to Luanda, Angola
27 Nov	Avianca	Int'l	Occurred near Madrid, Spain
12 Dec	Iberia	Int'l	Madrid to Rome

Table A.7 1984 Accidents

Date	Airline	Int'l or Domestic	Explanation
5 Aug	Bangladesh-Biman	Domestic	Chittagong to Dacca, Bangladesh
30 Aug	Cameroon	Domestic	Domestic flight

Table A.7 1985 Accidents

Date	Airline	Int'l or Domestic	Explanation
1 Jan	Eastern	Int'l	Occurred in mountain near La Paz,Bolivia
19 Jan	Cubana	Int'l	Havana to Managua
19 Feb	Iberia	Domestic	Madrid to Bilbao, Spain
15 Apr	Thai Airways		non-scheduled passenger flight
15 Jun	TWA	Int'l	Occurred in Beirut, Lebanon
23 Jun	Air India	Int'l	Occurred in Atlantic Ocean
2 Aug	Delta	Domestic	Fort Lauderdale to Dallas
12 Aug	JAL	Domestic	Tokyo to Osaka
6 Sep	Midwest Express	Domestic	Milwaukee to Atlanta
23 Nov	Egyptair	Int'l	Athens to Cairo

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